



# *Division Overview*

*Dawn Emerson*

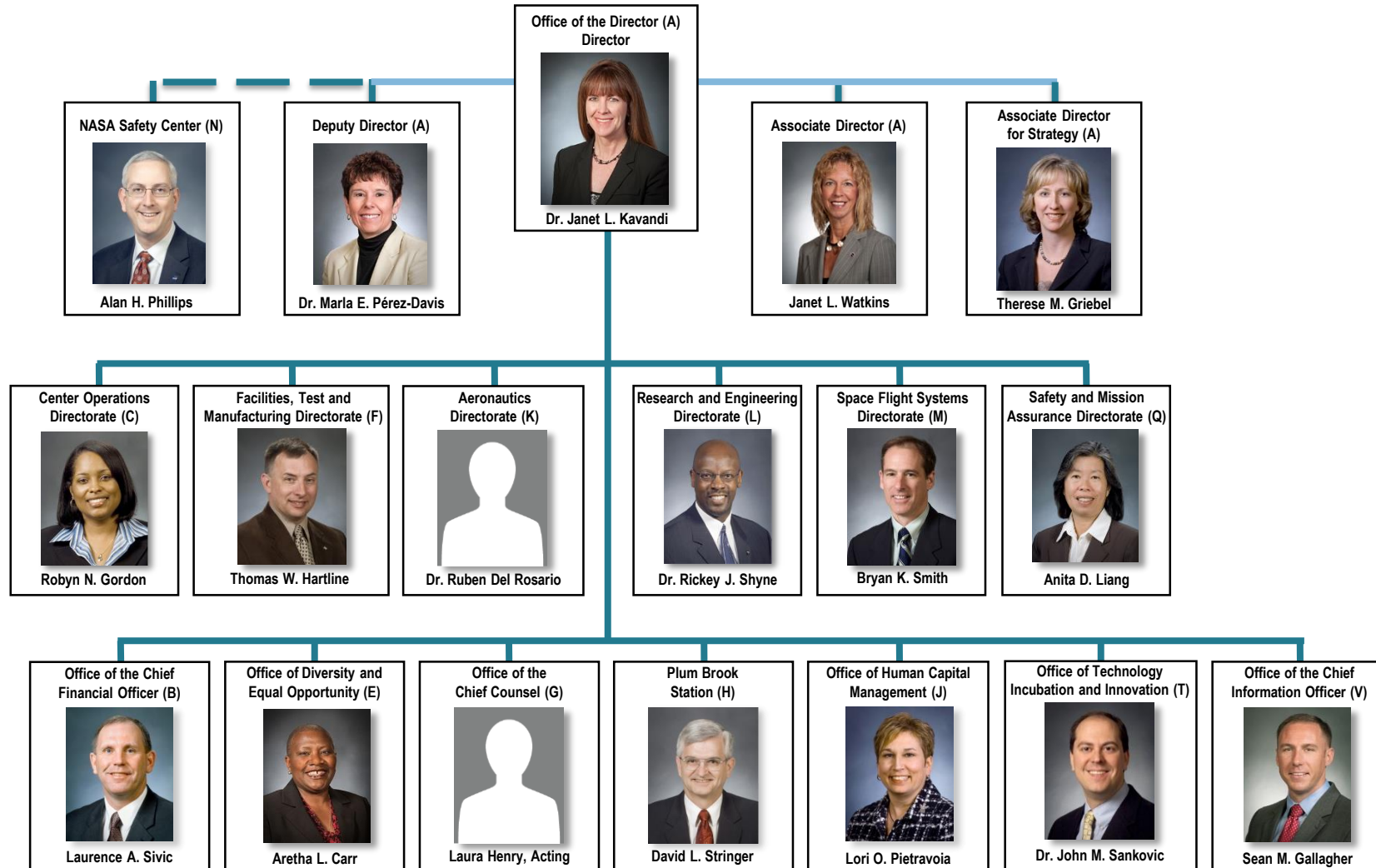
*November 10, 2016*

**COMMUNICATIONS &  
INTELLIGENT SYSTEMS DIVISION**

**NASA GLENN RESEARCH CENTER**



# Glenn Senior Management



\*Recruitment in progress



# Research and Engineering Directorate Leadership Team



**Deputy Director of  
Research and Engineering (L)**



Dr. Ajay K. Misra

**Director of  
Research and Engineering (L)**



Dr. Rickey J. Shyne

**Associate Director of  
Research and Engineering (L)**



Maria Babula

**Chief Engineer  
Office (LA)**



Richard T. Manella

**Management Support  
and Integration Office (LB)**



Susan Kolibas

**Communications and Intelligent  
Systems Division (LC)**



Dawn C. Emerson

**Power  
Division (LE)**



Randall B. Furnas

**Materials and Structures  
Division (LM)**



James J. Zakrajsek, Acting

**Systems Engineering and  
Architecture Division (LS)**



Derrick J. Cheston

**Propulsion  
Division (LT)**



Dr. George R. Schmidt



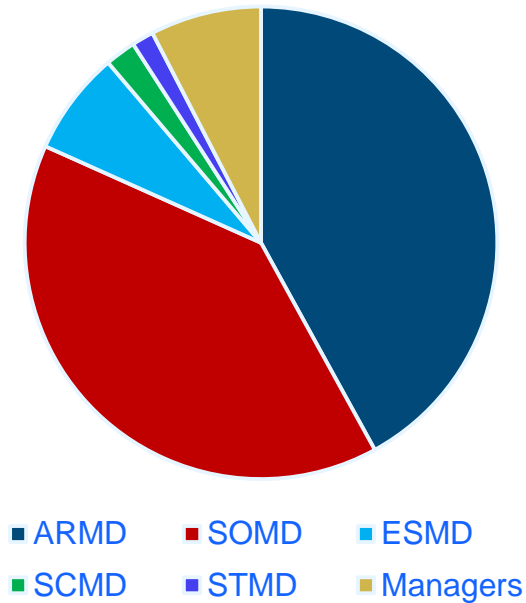


# Communications and Intelligent Systems Division (LC)



Provides expertise, plans, conducts and directs research and engineering in the competency fields of advanced communications and intelligent systems with emphasis on advanced technologies, architecture definition and system development for application in current and future aeronautics and space systems.

LC Support to Mission Directorates



## LC Competency Elements:

### Space Communications (SpaceComm) & Aeronautical Communications (AeroComm)

Expertise:

- Networks & Architectures
- Information & Signal Processing
- Advanced High Frequency
- Optical Communications

### Intelligent Systems – Cross-Cutting Competencies

Expertise:

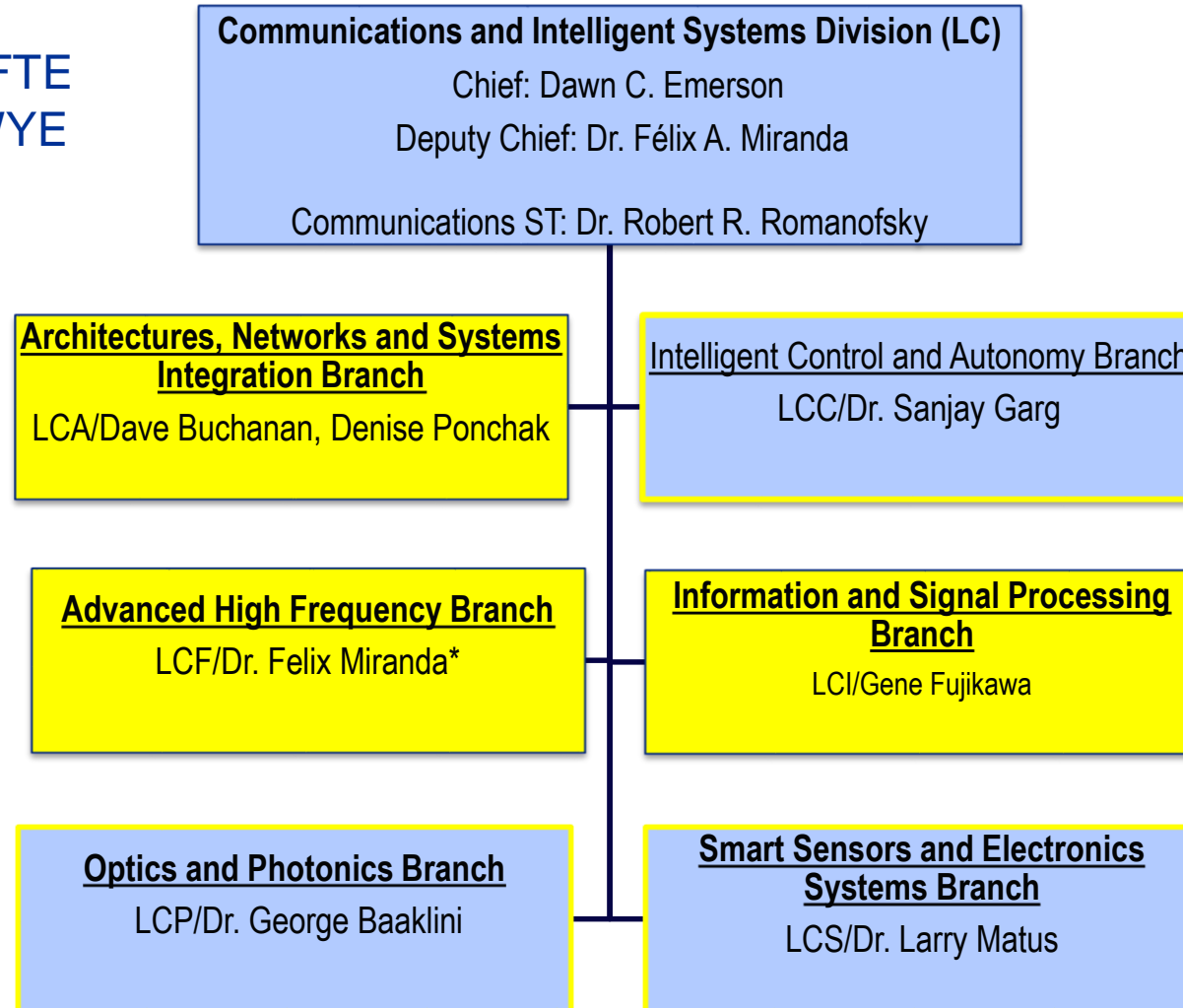
- Optics and Photonics
- Smart Sensor Systems
- Instrumentation- Electronic
- Controls- Dynamic System Modeling and Controls



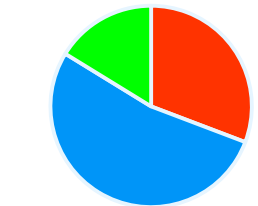
# Communications and Intelligent Systems Division (LC)



115 FTE  
58 WYE



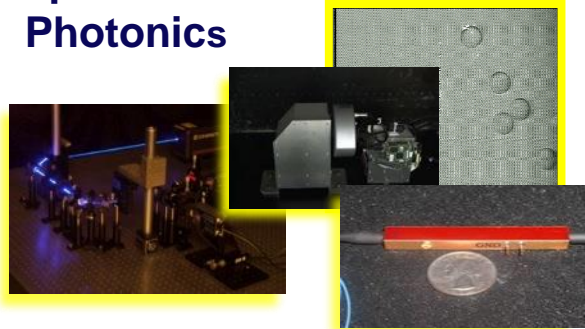
## Education



■ PhD ■ MS ■ BS

\* Acting

## Optics and Photonics



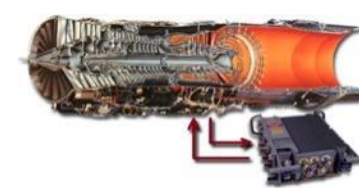
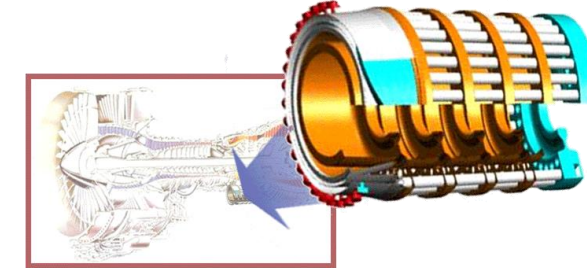
Optical Instrumentation  
Optical Communications  
Health Monitoring

## Architectures, Networks and Systems Integration



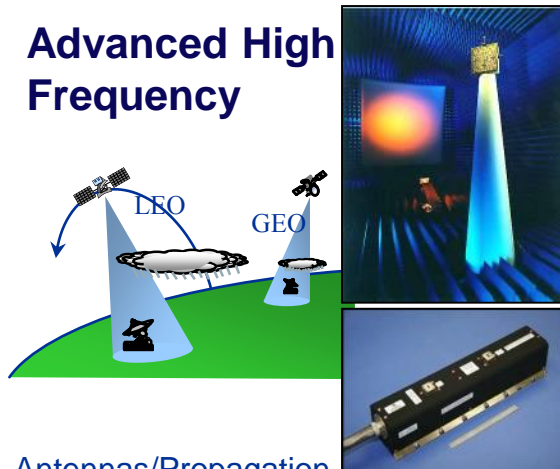
Communications Architectures  
Modeling and Simulation/Tech Demos  
Spectrum and Link Analysis

## Intelligent Control and Autonomy



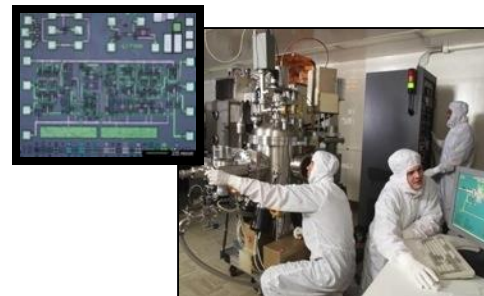
Intelligent Controls  
Dynamic Modeling  
Health Management

## Advanced High Frequency



Antennas/Propagation  
RF Systems and Components  
3-D Electromagnetic Modeling

## Smart Sensors and Electronics Systems



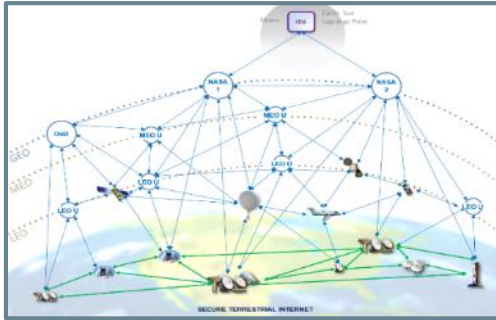
Thin Film Physical Sensors  
High Temp/Harsh Environment Focus  
Wireless Technologies

## Information and Signal Processing



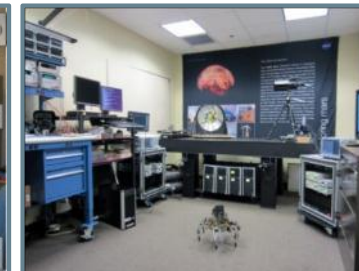
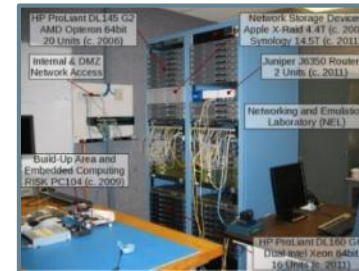
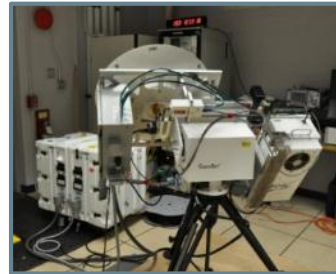
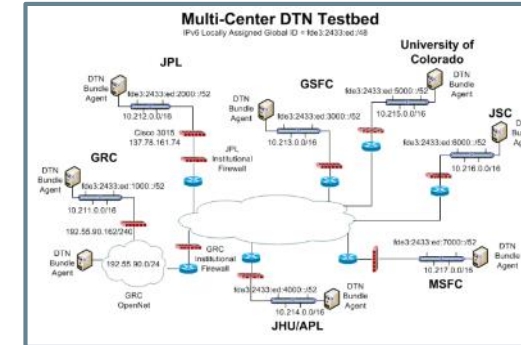
Radio Systems – SDRs, Cognitive  
Bandwidth and Power-Efficiency  
Waveform Development





## Communications Systems

- Systems engineering of future SCA Integrated Network Architecture.
- Requirements decomposition, systems definition, development, hardware and software build up, test and delivery of Space Network compatibility test unit including TDRS signal simulator.



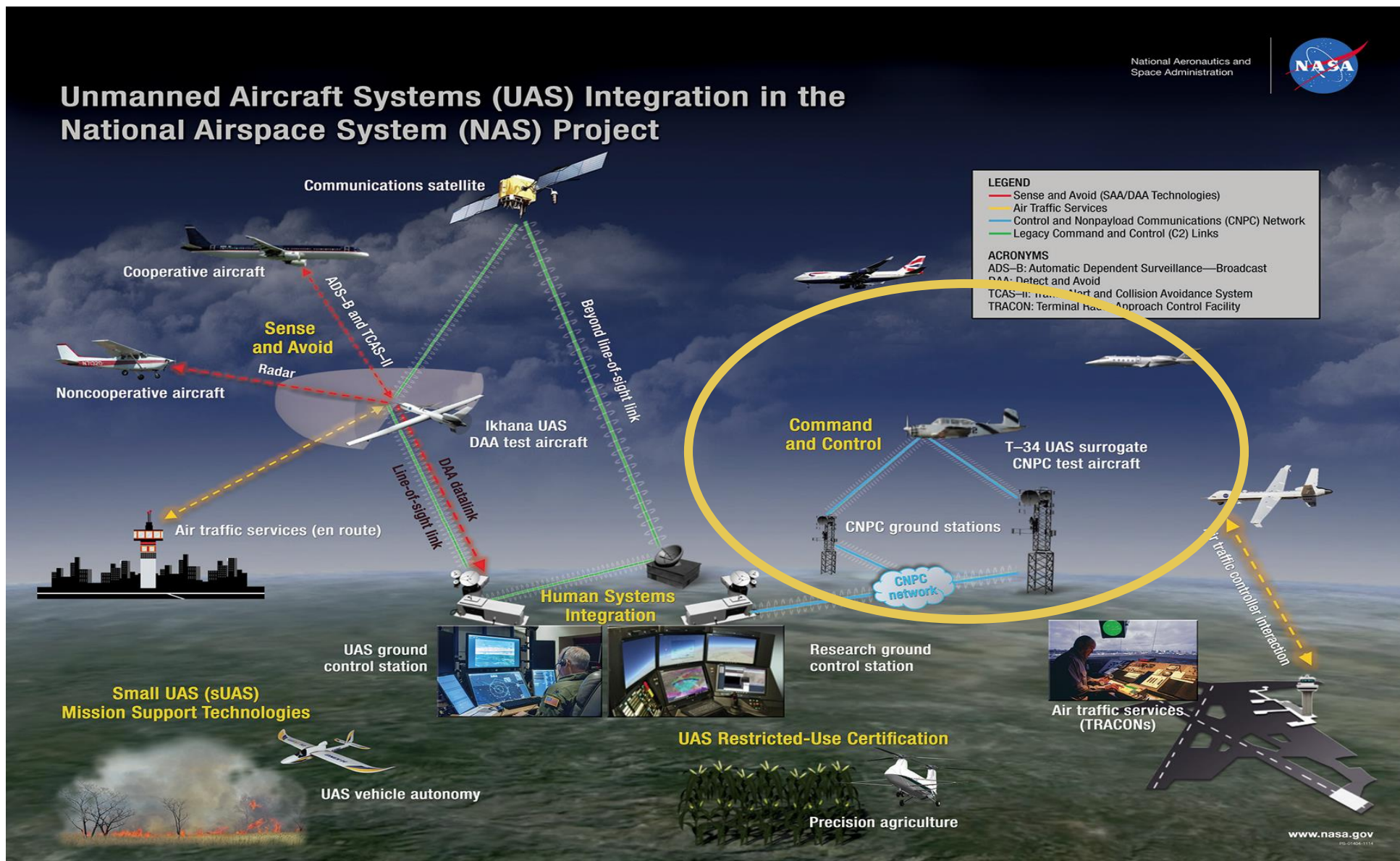
## Aeronautical Communications

- Includes air-to-air, air-to-ground, and ground-based mobile wireless communications, information networking, navigation and surveillance research, technology development, testing and demonstration, advanced concepts and architectures development, and national and international technology standards development.



## Network Research

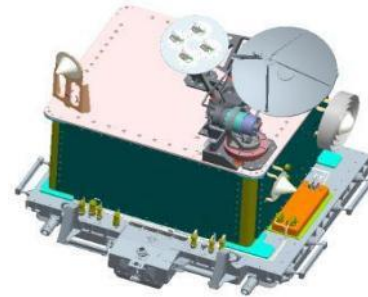
- Development of network components, design of network layers and networked systems architectures. Emphasis is on secure wireless mobility, protocol characterization and development, requirements definition, and flight software/hardware component assessment. Also includes "virtual" mission operations.





## LCI Overview

Conducts research and technology development of information and signal processing methods and approaches of digital communications systems for aerospace applications. Emphasis on software-defined and cognitive radios; open SDR architectures and waveform development; position, navigation and timing methods; spectrum and power efficient techniques; reconfigurable microelectronic devices

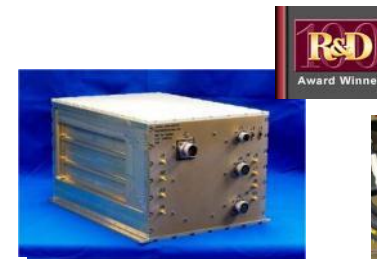


SCaN Testbed

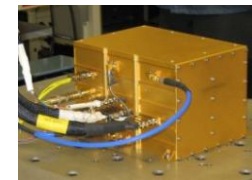


## Facilities/Labs

- Software-Defined and Cognitive Radio Technology Development Laboratory
- Digital Systems and Signal Processing Lab
- EVA Radio and Integrated Audio Lab
- SCan Testbed on ISS Available for Experimenters



Software Defined Radios

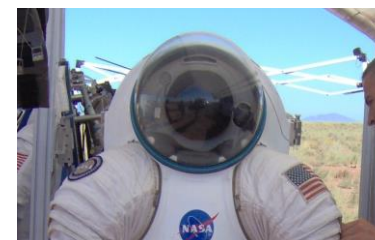


## Focus Areas

- Software-Defined and Cognitive Radios
  - Space Telecommunications Radio System (STRS)
  - STRS-compliant Hardware and Software
  - SDR Waveform Development
  - Digital Core for RF/Optical Terminal
- High Speed Signal Processing
  - Computer Modeling and Simulation Tools
  - Wireless and Microelectronic Devices for Communications
- Advanced Exploration Systems
  - Integrated Audio/Microphone Arraying
  - EVA Radio Development
  - Surface Navigation
- SCan Testbed Flight Radio Experiments and Demonstrations
  - GPS Navigation and Timing
  - Ka-Band, Bandwidth-Efficient, High Rate Waveform
  - S- and Ka-Band IP Networking and Routing
  - Adaptive Modulation and Coding for Cognitive Radio



Extra-Vehicular Activity (EVA) Radio



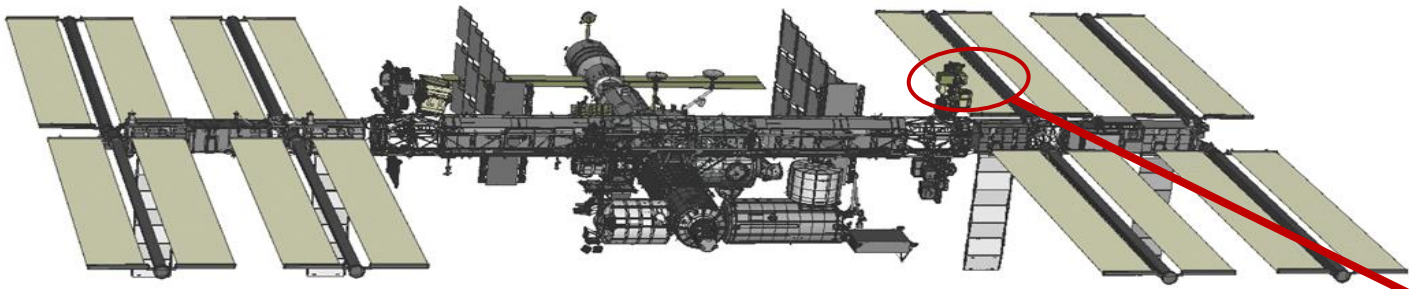
AES/EVA Integrated Audio



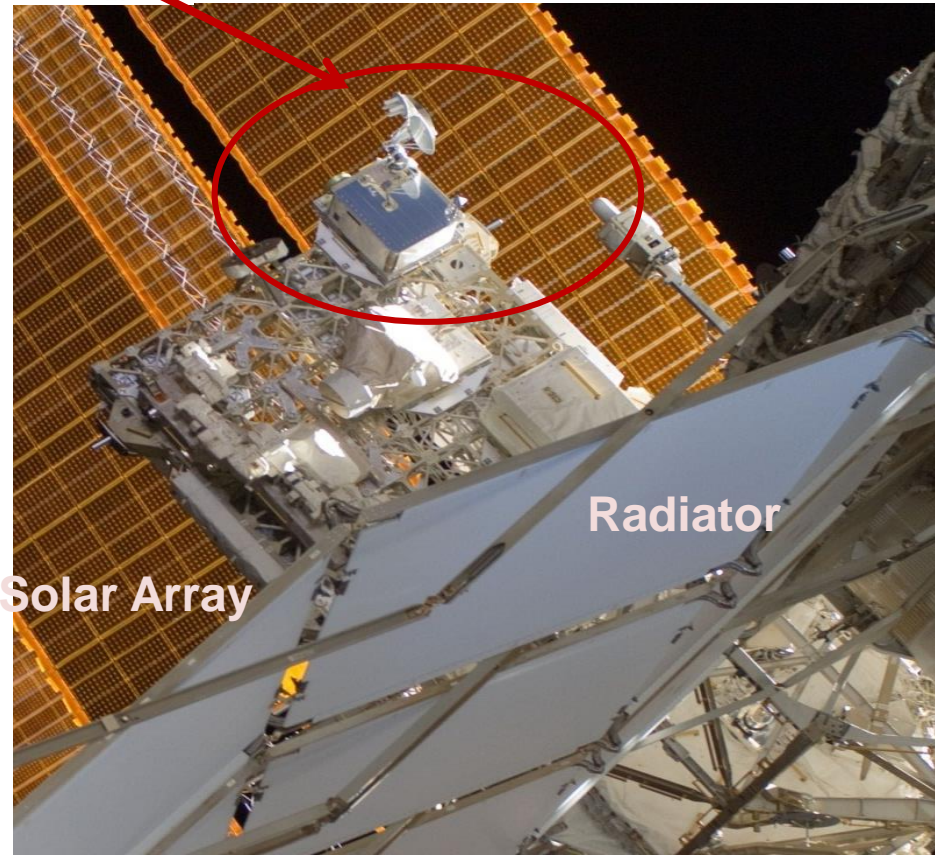
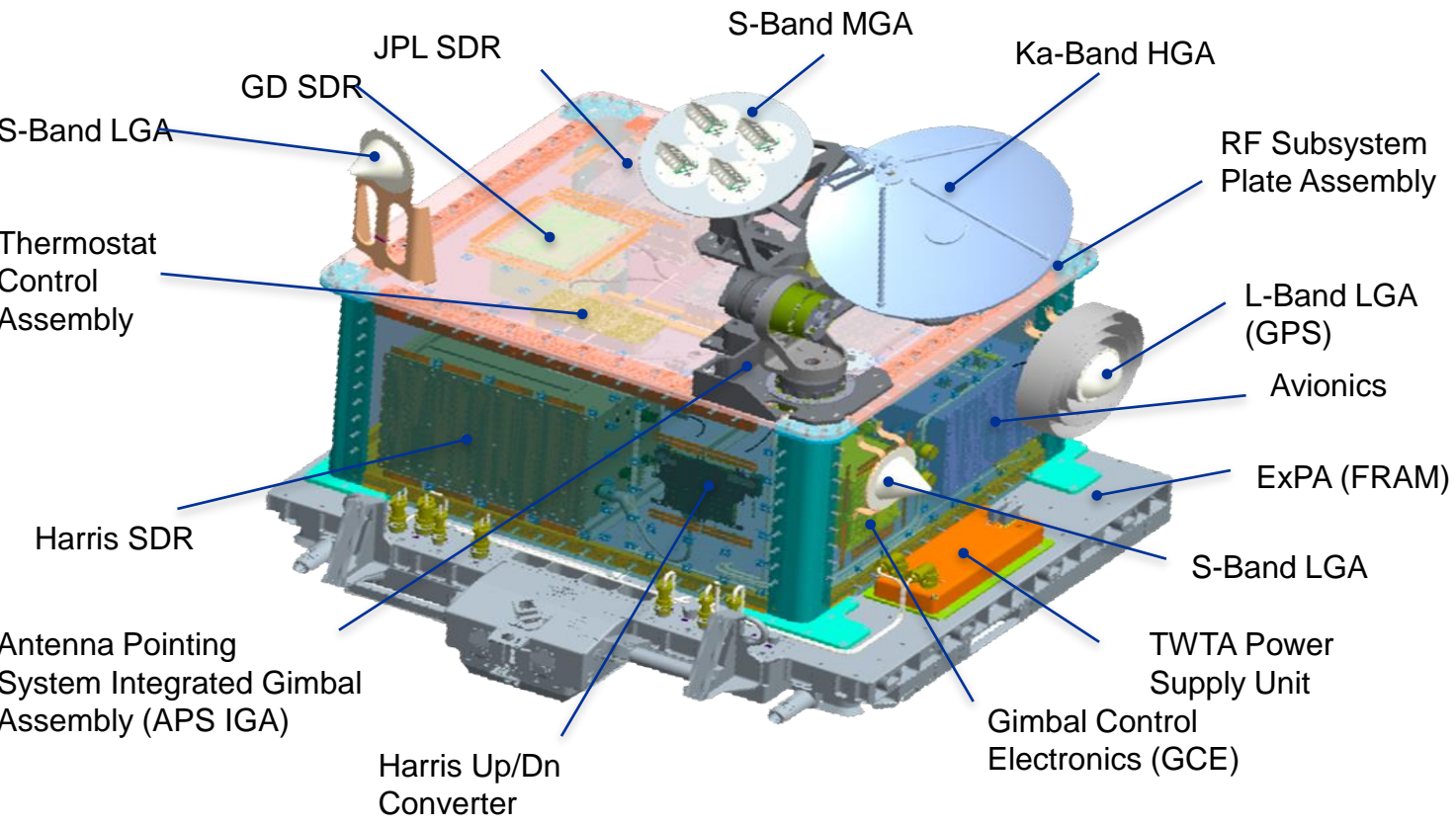
iROC Flexible Digital Core



# Space Communication and Navigation Testbed



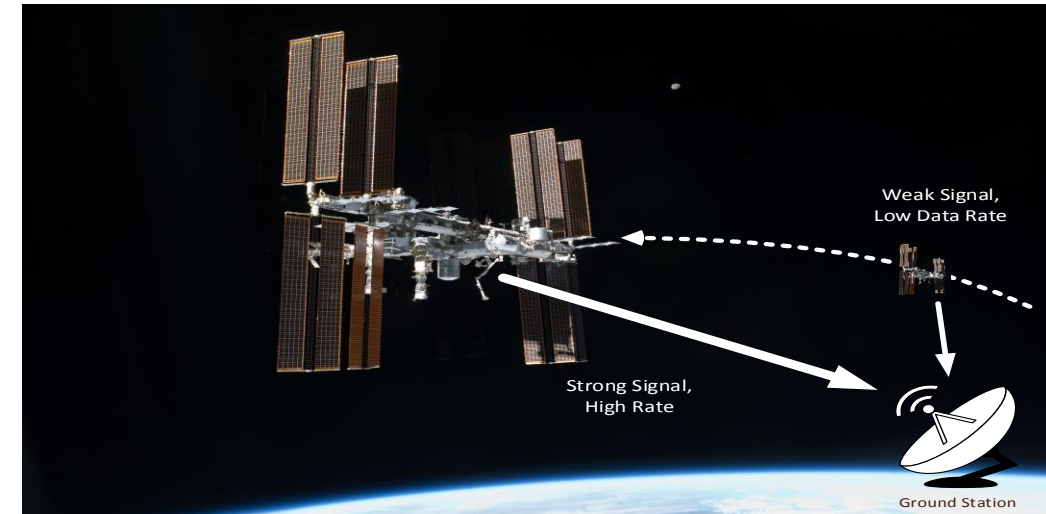
**SCaN Testbed aboard International Space Station**



Goal: Develop next generation cognitive technologies for communications to increase mission science return and improve resource efficiencies.

SCaN Test Bed is an early proving ground for experiments in cognitive communications

- Performed experiments in VCM and ACM
- Moving toward cognitive communications
  - Enhanced adaptive capability- More efficient use of spectrum, power and network resource management. Adapt mission operations based on internal and external environments.



Automatically compensate for dynamic link environment

SDR

Configurable  
Properties

Variable Coding &  
Modulation (VCM)

Reconfigure system  
based on predictions

Adaptive Coding &  
Modulation (ACM)

Dynamic reconfiguration  
based on feedback

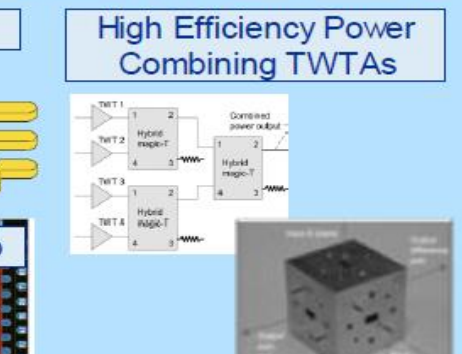
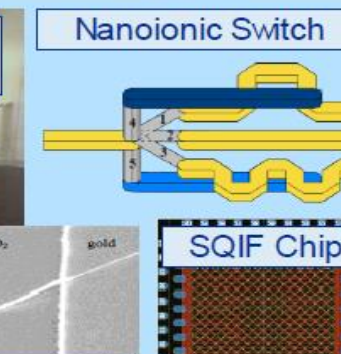
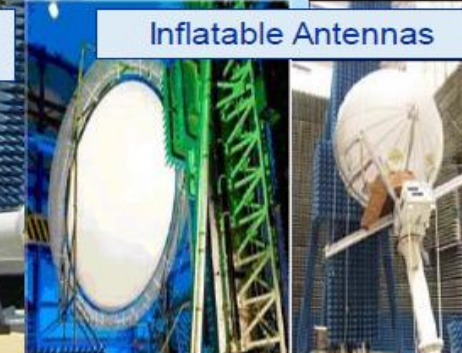
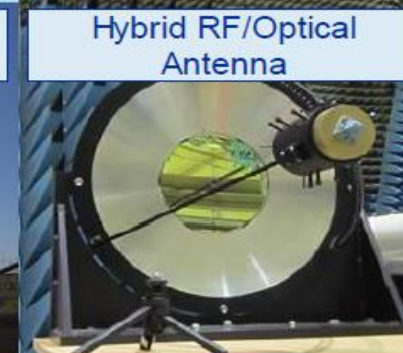
Cognitive  
Radio/System

Adapting and learning to form  
intelligent systems: cognitive radios,  
intelligent networking, user initiated  
services



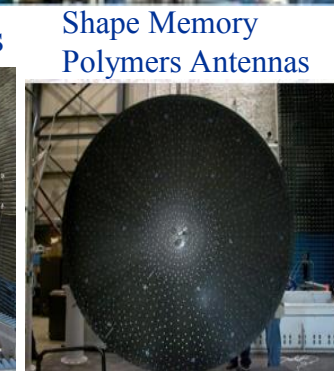
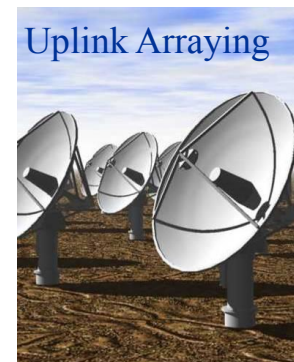
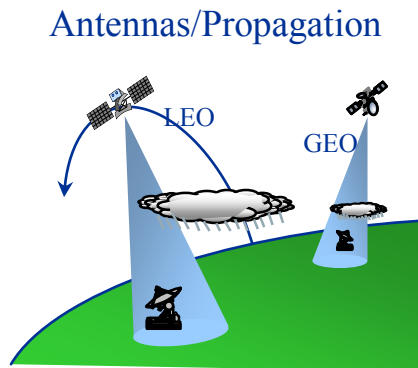
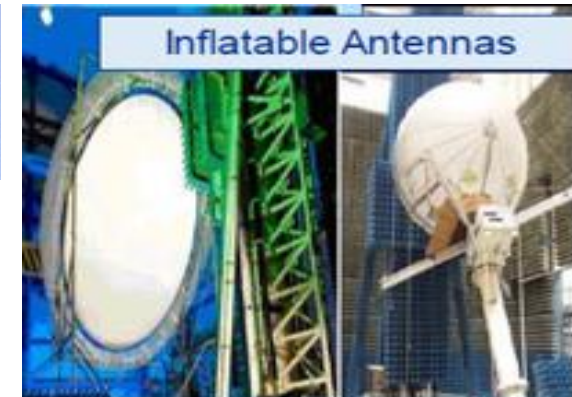
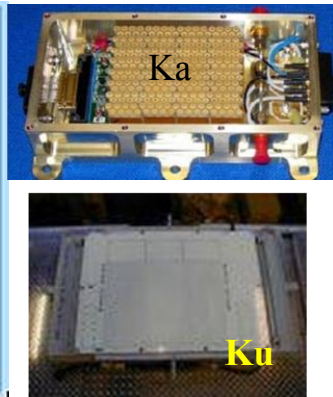
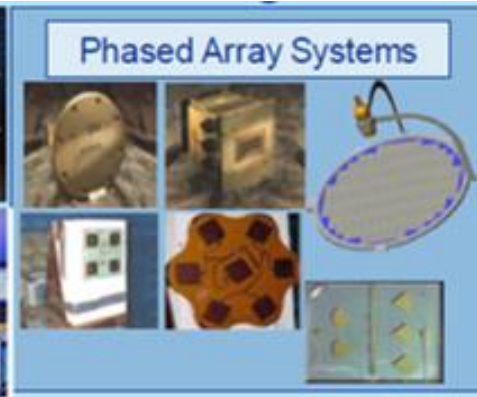
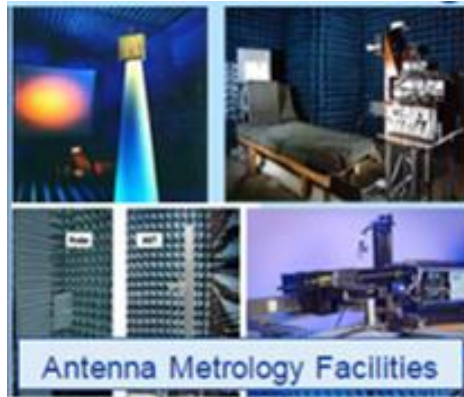
## Branch Overview

- Conducts research and technology development, integration, validation, and verification at frequencies extending up to the terahertz region in the areas of semiconductor devices and integrated circuits, antennas, power combiners, frequency and phase agile devices for phased arrays, and radio wave propagation through Earth's atmosphere, in support of NASA space missions and aeronautics applications.
- R&D is conducted in-house and also in collaboration with academia and industry to develop low mass, small size, high power and efficiency traveling-wave tube amplifiers, solid state power amplifiers; novel antenna technologies (e.g., wideband antennas, hybrid antennas (i.e., RF/Optical), ground stations, among others.
- The Branch supports development of advanced technologies such as superconducting quantum interference filter (SQIF) for ultra-sensitive receivers and Ka-band multi-access arrays for NASA's next generation space communications.
- Facilities include planar and cylindrical near-field, far-field and compact antenna ranges, cryogenic microwave and millimeter-wave device and circuit characterization laboratory, high power amplifier characterization laboratory, radio wave propagation laboratory, and clean room facilities.
- Semiconductor device modeling and high frequency circuit simulation, fabrication, and integration facilities are also available.

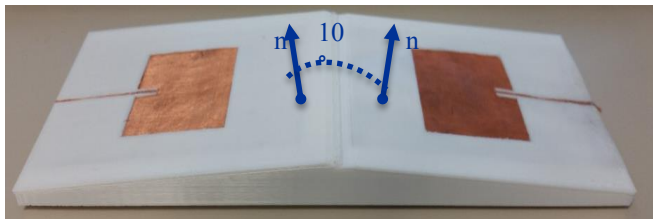




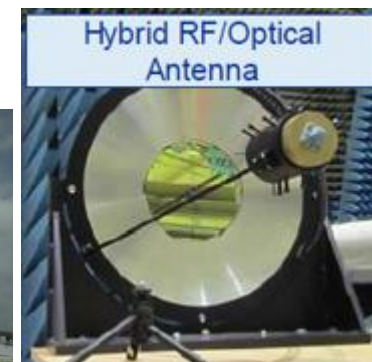
# Advanced RF Antenna and Optical Technologies



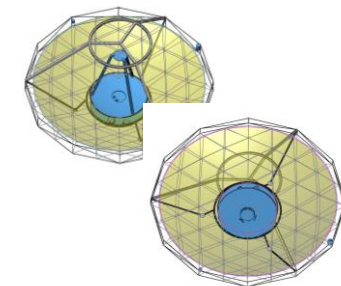
3-D Printed Antennas for Cubesats



SCaN Testbed  
Ground Station

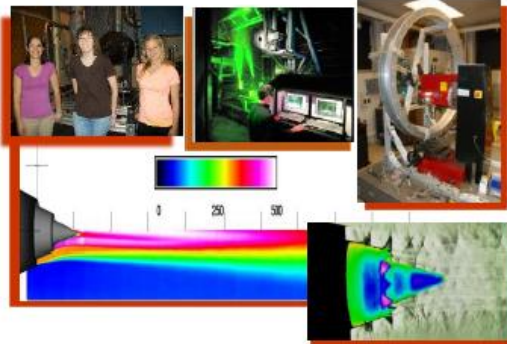


Teletenna Concept





## Optical Instrumentation



<http://www.grc.nasa.gov/WWW/Optinstr/>

- Our data and instrumentation help designers understand the fundamental physics of new systems, validate aeronautics computational and life models, and improve space optical communications for human and robotic explorations.

- Our data leads to improved designs, validation and verification of systems performances, increased communications, safety and security and reduced design cycle times for many of the core technologies developed at Glenn and across NASA.

## Photonics and Health Monitoring



### Flow/Noise Diagnostics

- Particle imaging Velocimetry (PIV)
- Background Oriented Schlieren
- Rayleigh Scattering
- PIV Tomography
- Combustion diagnostics
- Raman Diagnostics (Species, T)
- Plasma generation

### Surface Diagnostics

- Temperature Sensitive Paint
- Pressure Sensitive Paint
- Stress Sensitive Film

### Engine Icing

- Light Extinction Tomography
- Light Extinction Probes
- Raman Spectroscopy
- Impedance Sensor

## Optical Communications



### Free Space Communications

- Optical Teletennas
- Beaconless Pointing Systems
- High Data Rate for Deep Space & Near Earth

### Secure Quantum Communications

- Quantum Entanglement
- Pulsed photon Pairs
- Quantum Illumination
- Quantum Key Distributions

### Mobile and Remote Sensing

- On-Orbit Solar Cell Characterization MISSE 5-8; TACSAT- 4;
- Hyperspectral Imaging
- Mobile Sensing Platforms

### Communications

- Communications over power lines
- Communications Interface Boards
- High Data Rate

### Health Monitoring

- Microwave Blade Tip Clearance
- Self diagnostic Accelerometer
- Fiber optics sensors
- Morphology dependent resonance
- Phosphor Thermography
- Capacitance & piezo patches sensors
- Wireless and wired techniques



## Current status

- Airborne hyperspectral sensing capability for monitoring potentially harmful algal blooms
- 14 flights in 2014, 26 flights in 2015 and 6 flights this year
- Provide HAB data on water intakes in Lake Erie, small lakes and the Ohio river

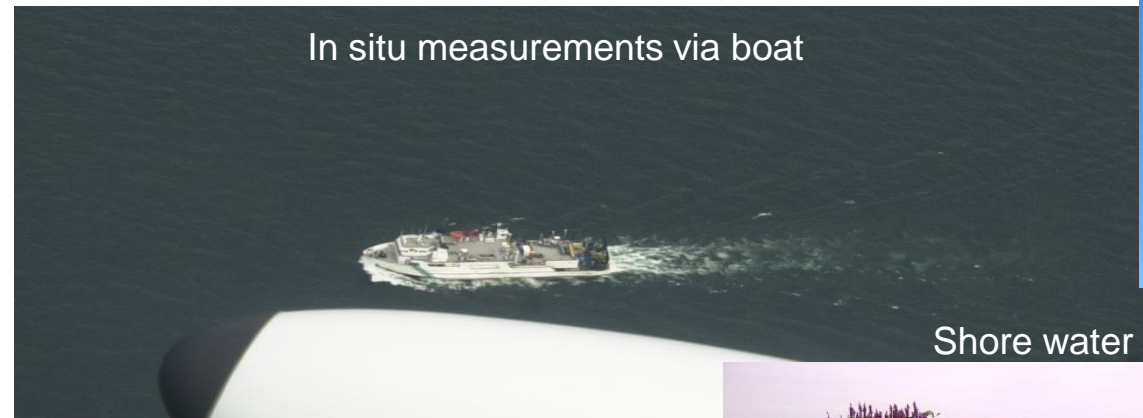
## Research partners also conduct water sampling and ground optical measurements

- NOAA GLERL
- University of Toledo
- Kent State University
- Michigan Tech Research Institute
- Bowling Green State University
- OhioView
- Naval Research Lab

***HAB information provided by remote sensing and water sampling can provide for early warning to ensure proper water treatment and shutoff avoidance***



NASA aircraft



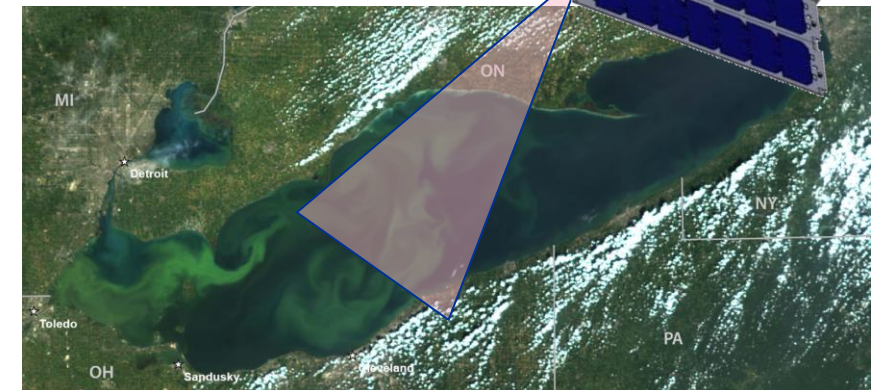
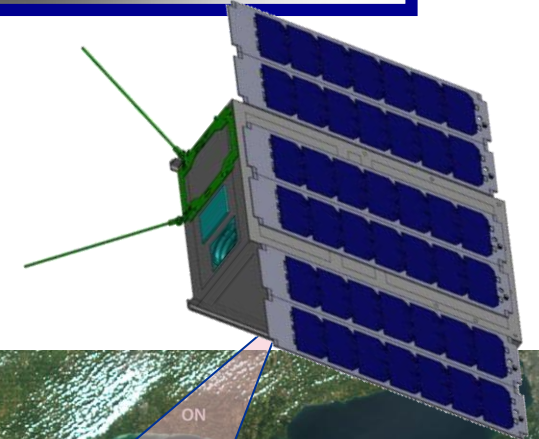
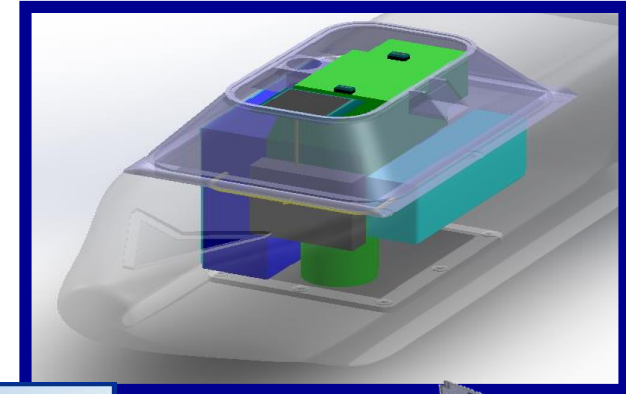
Shore radiance measurements



Shore water sa



- New Platforms:
  - Integrate a hyperspectral imager into an unmanned aerial vehicle (UAV) starting in August 2016
  - Two hyperspectral imagers in development that are appropriate for a cubesat
- New Algorithms
  - Mirror based atmospheric correction
  - Verimax rotated principal component analysis
  - Tuned Cyanobacteria index





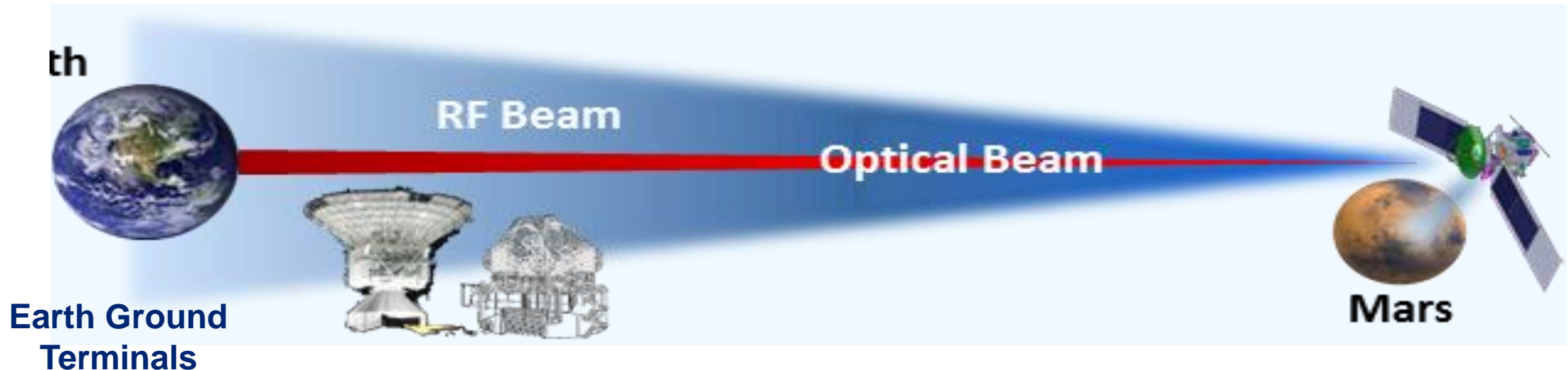
# Integrated Radio and Optical Communications (iROC)

## iROC Objectives:

- Combine the best features of deep space RF and optical communications elements into an integrated system:
- Increase data throughput while reducing spacecraft mass, power and volume.
- Extensible to, and mitigates risk for missions from near Earth to deep space.
- Prototype and demonstrate performance of key components to increase TRL, leading to an integrated hybrid communications system demonstration.

## Key enabling technologies :

- Combined RF/optical Teletenna
- Precision beaconless pointing /navigation through sensor fusion
- RF/optical Software Defined Radio (SDR)
- Networked RF/optical link management (DTN)





## Description

Conducts research and development of adaptable instrumentation to enable intelligent measurement systems for ongoing and future aerospace propulsion and space exploration programs. Emphasis is on smart sensors and electronics systems for diagnostic engine health monitoring, controls, safety, security, surveillance, and biomedical applications; often for high temperature/harsh environments.



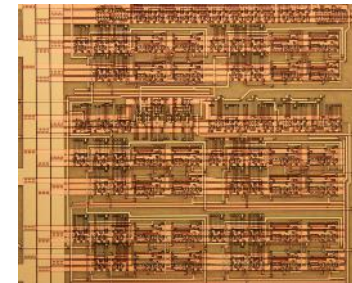
**Microsystems Fabrication Facility**

## Facilities/Labs

- Microsystems Fabrication Facilities
  - Class 100 Clean Room
  - Class 1000 Clean Room
- Chemical vapor deposition laboratories
- Chemical sensor testing laboratories
- Harsh environment laboratories
  - Nanostructure fabrication and analysis
  - Sensor and electronic device test and evaluation

## Focus Areas

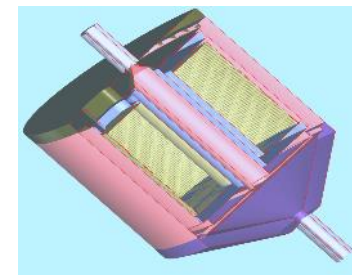
- Silicon Carbide (SiC) - based electronic devices
  - Sensors and electronics for high temp (600°C) use
  - Wireless sensor technologies, integrated circuits, and packaging
- Micro-Electro-Mechanical Systems (MEMS)
  - Pressure, acceleration, fuel actuation, and deep etching
- Chemical gas species sensors
  - Leak detection, emission, fire and environmental, and human health monitoring
- Microfabricated thin-film physical sensors
  - Temperature, strain, heat flux, flow, and radiation measurements
- Harsh environment nanotechnology
  - Nano-based processing using microfabrication techniques
  - Smart memory alloys and ultra low power devices



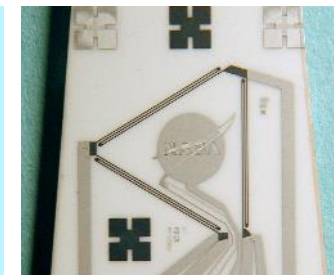
SiC Signal Processing



Chemical Gas Sensors

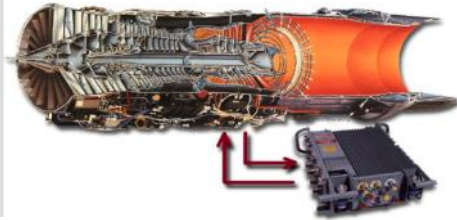


MEMS Fuel Actuation



Thin Film Physical Sensors

## Propulsion Controls



### Active Combustion Control

Control of Thermo-acoustic Instability  
High Bandwidth Fuel Actuation

### Advanced Control Architecture

Distributed Engine Control  
Hardware-in-the-loop Test-bed

### Intelligent Engine Control

Enhanced Engine Response for  
Emergency Operations

Robust Engine Control

Model-Based Engine Control

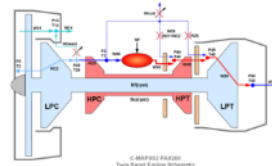
V&V of Advanced Controls

### High Speed Propulsion

Aero-Propulso-Servo Elasticity for  
Supersonic Propulsion System

Mode Transition Management for Air-  
Breathing Hypersonic Propulsion

## Health Management



### Propulsion & Power Systems

Gas Path Health Management  
Sensor Selection

Sensor Data Qualification

Fault Modeling and Diagnostics

Model-Based Engine Simulation for  
Engine Test, Calibration and  
Performance Analyses

## Current NASA Programs

### Aeronautics Research Mission

Advanced Air Vehicle

Airspace Operations and Safety

Transformative Aeronautics Concepts

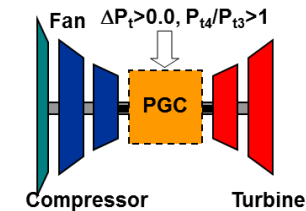
### Human Exploration and Operations Mission

Space Launch System

SCAN

Orion

## Advanced Propulsion Concepts



### Unsteady Propulsion

Pulse Detonation Engine  
Pressure Gain Combustion

## Communications

### Integrated Radio and Optical Comm

Spacecraft Attitude Estimation  
Spacecraft Structural Dynamics

## Software Tools

### Engine Modeling & Control

C-MAPSS (Commercial Modular Aero  
Propulsion System Simulation)

C-MAPSS40k (40,000 lb Thrust Engine)

T-MATS (Tool for Modeling and Analysis  
of Thermodynamic Systems)

Combustion Instability Simulation